



# State of CERES



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CERES Science Team Meeting, October 12-14, 2021  
Virtual Meeting

# CERES Science Team Meeting

- Review status of CERES Instruments and Data Products
- Invited Presentations Session. Each presentation is 45 min including time for questions.
- Contributed Science Reports. Each report is 20 min including time for questions.

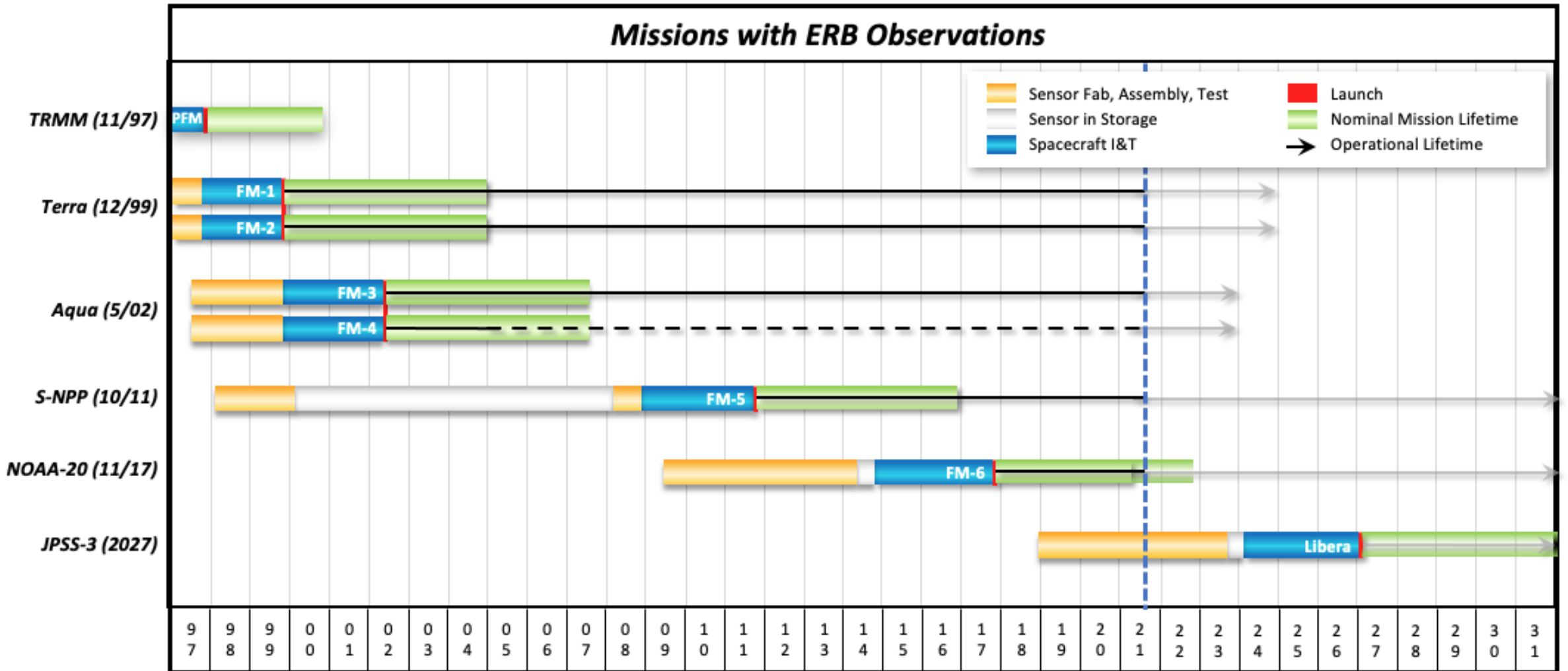
***Please send an electronic copy of your presentation to Ed Kizer (edward.a.kizer@nasa.gov) at least one day prior to your presentation***

# CERES Technical Meeting

## Review Status of CERES Instruments and Data Products:

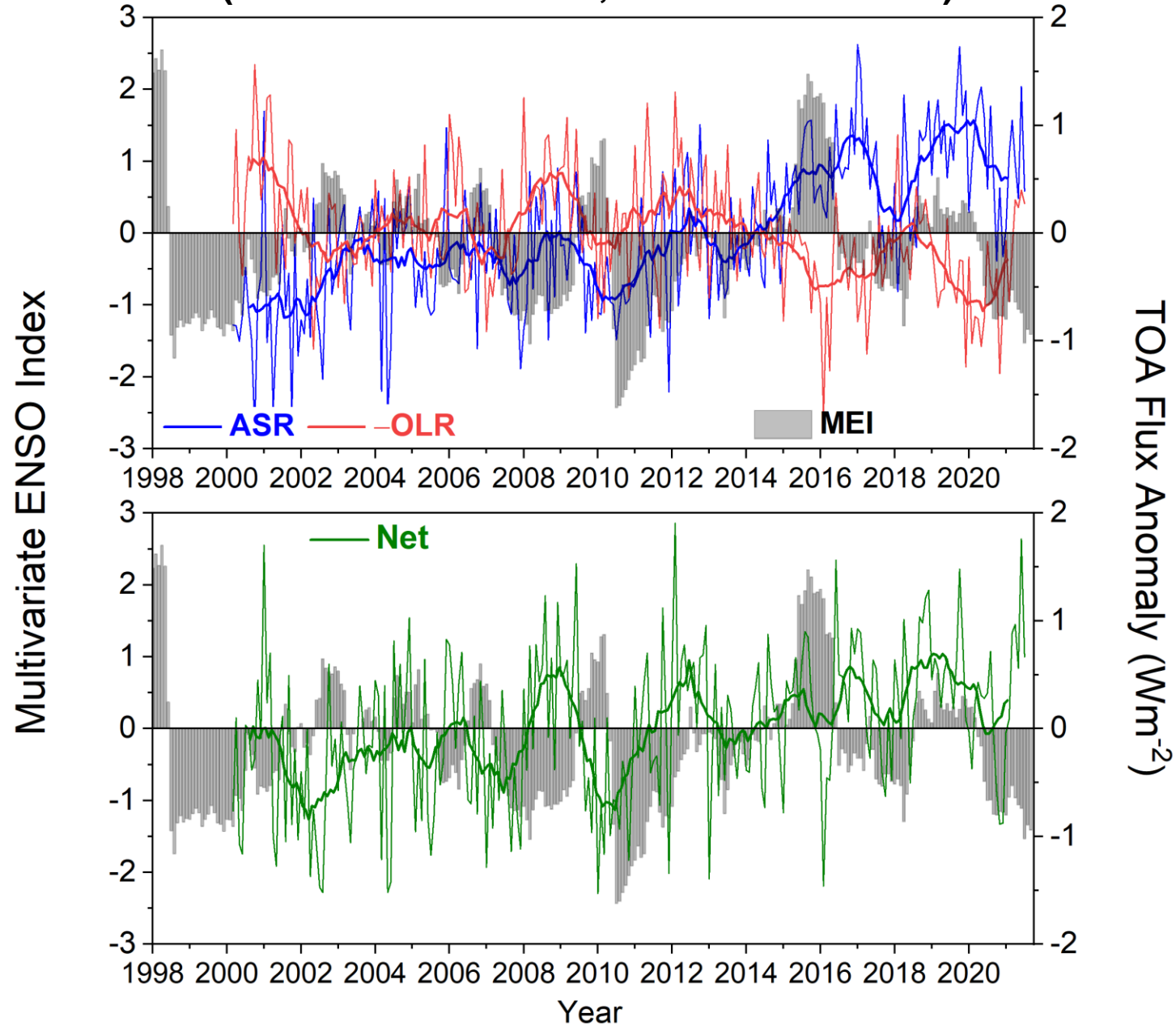
- State of CERES
- CERES Terra, Aqua, S-NPP, NOAA-20 Instrument Calibration Update
- MODIS & VIIRS Cloud Algorithm & Validation Status
- ADM, SARB and TISA Working Group Reports
- EBAF Update
- FLASHFlux Update
- Data Management Team Update

# Flight Schedules



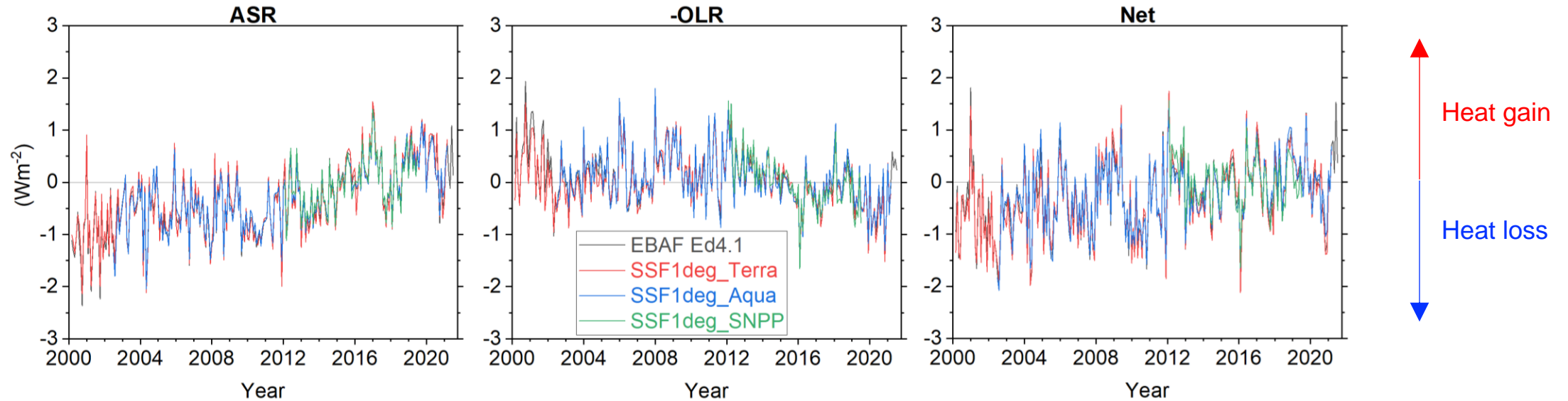
- Currently, 6 CERES instruments fly on 4 satellites: Terra (L1999), Aqua (L2002), SNPP(L2011), NOAA-20 (L2017)

# Global Mean All-Sky TOA Flux Anomalies & Multivariate ENSO Index (CERES EBAF Ed4.1; 03/2000 – 07/2021)



# Global Mean All-Sky TOA Flux Anomalies

(Relative to Climatology for 02/2012-09/2019)



## EBAF Trends (03/2000-07/2021)

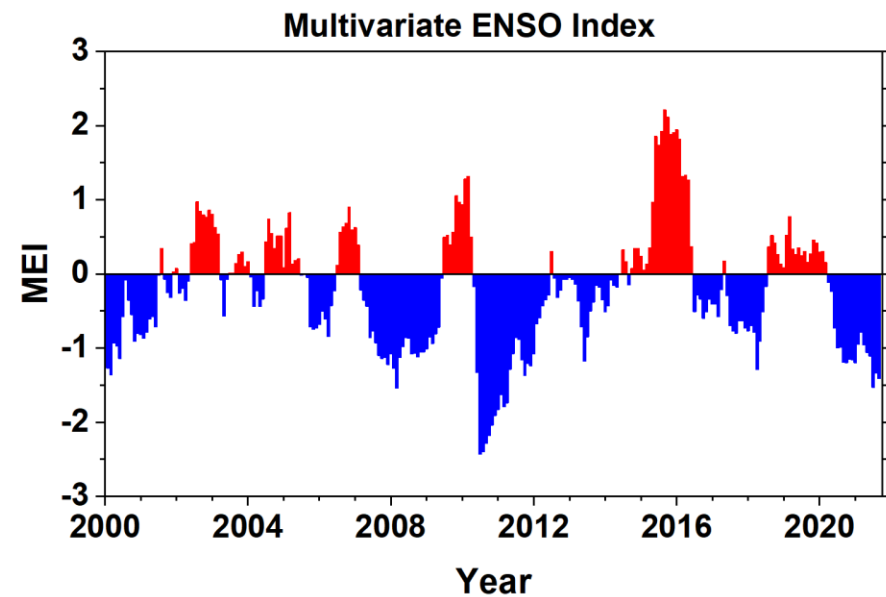
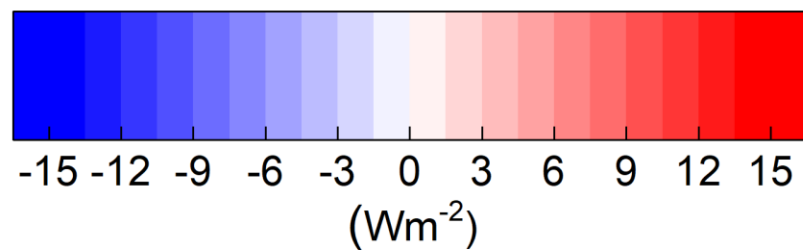
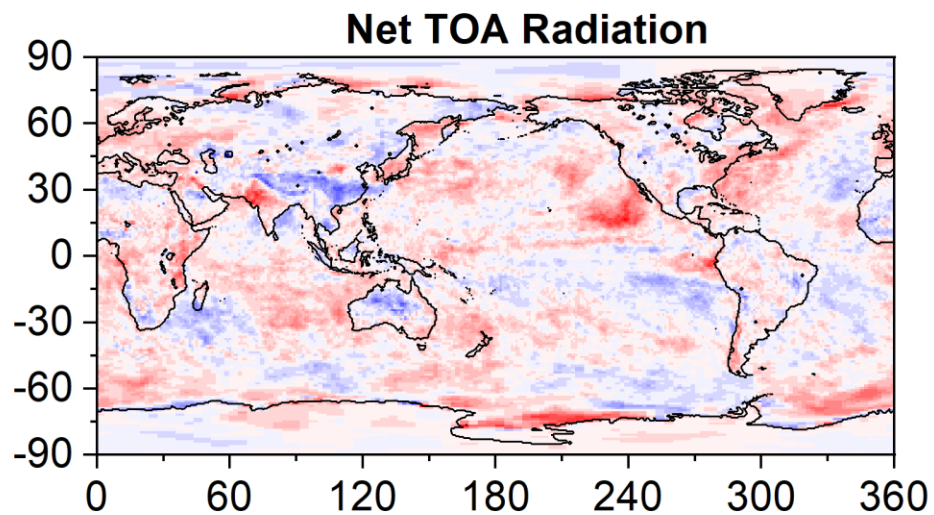
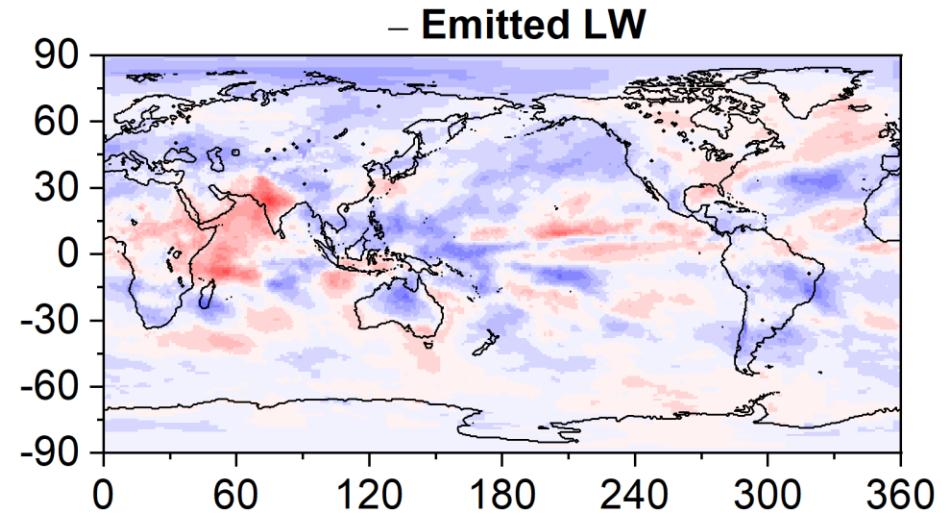
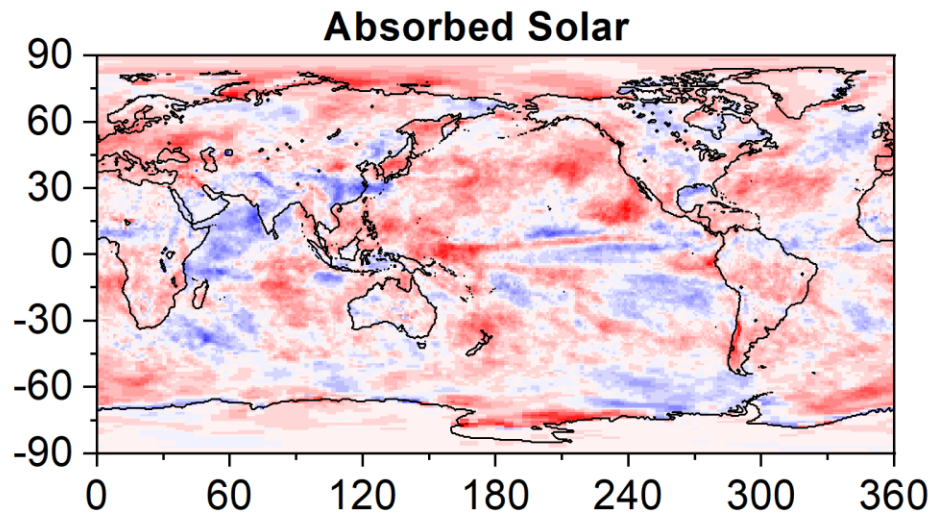
$0.68 \pm 0.14$  Wm<sup>-2</sup> per decade

$-0.28 \pm 0.14$  Wm<sup>-2</sup> per decade

$0.40 \pm 0.17$  Wm<sup>-2</sup> per decade

- Earth's energy imbalance (EEI) averaged over 2005-2015 is  $0.71 \pm 0.1$  Wm<sup>-2</sup> (Johnson et al. 2016)
  - A trend in global mean net TOA flux of  $0.40$  Wm<sup>-2</sup> per decade implies an increase of  $\approx 0.80$  Wm<sup>-2</sup> in EEI during the 20-year CERES record.
- **Earth's heating rate has shown a marked increase since 2000**

# TOA Radiation Changes (03/2000 – 07/2021)





# Media Pickup



## Geophysical Research Letters

### RESEARCH LETTER

10.1029/2021GL093047

#### Key Points:

- Satellite and in situ observations independently show an approximate doubling of Earth's Energy Imbalance (EEI) from mid-2005 to mid-2019
- Anthropogenic forcing, internal variability, and climate feedbacks all contribute to the positive trend in EEI
- Marked decreases in clouds and sea-ice and increases in trace gases and water vapor combine to increase the rate of planetary heat uptake

#### Correspondence to:

N. G. Loeb,  
[norman.g.loeb@nasa.gov](mailto:norman.g.loeb@nasa.gov)

#### Citation:

### Satellite and Ocean Data Reveal Marked Increase in Earth's Heating Rate

Norman G. Loeb<sup>1</sup> , Gregory C. Johnson<sup>2</sup> , Tyler J. Thorsen<sup>1</sup> , John M. Lyman<sup>2,3</sup>, Fred G. Rose<sup>4</sup> , and Seiji Kato<sup>1</sup> 

<sup>1</sup>NASA Langley Research Center, Hampton, VA, USA, <sup>2</sup>NOAA/Pacific Marine Environmental Laboratory, Seattle, WA, USA, <sup>3</sup>Joint Institute for Marine and Atmospheric Research, University of Hawaii at Manoa, Honolulu, HI, USA, <sup>4</sup>Science Systems and Applications, Inc., Hampton, VA, USA

**Abstract** Earth's Energy Imbalance (EEI) is a relatively small (presently  $\sim 0.3\%$ ) difference between global mean solar radiation absorbed and thermal infrared radiation emitted to space. EEI is set by natural and anthropogenic climate forcings and the climate system's response to those forcings. It is also influenced by internal variations within the climate system. Most of EEI warms the ocean; the remainder heats the land, melts ice, and warms the atmosphere. We show that independent satellite and in situ observations each yield statistically indistinguishable decadal increases in EEI from mid-2005 to mid-2019 of  $0.50 \pm 0.47 \text{ W m}^{-2} \text{ decade}^{-1}$  (5%–95% confidence interval). This trend is primarily due to an increase in absorbed solar radiation associated with decreased reflection by clouds and sea-ice and a decrease in outgoing longwave radiation (OLR) due to increases in trace gases and water vapor. These changes combined exceed a positive trend in OLR due to increasing global mean temperatures.



CNN

Washington Post

E&E

Scientific American

Harper's Magazine

The Guardian

The Independent

BBC Science in Action

Gizmodo/Earther

Yahoo! News

Fox News

Seattle Times

The Week

The Hill

MSN

Sydney Morning Herald

World Economic Forum

Daily Mail

Business Insider

Weather Channel

Tech Times

India Times

SF Gate

IFL Science

NY Post

UNILAD

The Verge

AllTop Viral



# Geophysical Research Letters



## RESEARCH LETTER

10.1029/2021GL092994

### Key Points:

- The Sun is not causing climate change and Cloud Radiative Forcing (CRF) signals can now be detected immediately
- Arctic heating is being balanced by reflectivity increases elsewhere
- The calibration accuracy of data is sufficient to detect uncertain cloud feedback signals immediately, rather than in decades

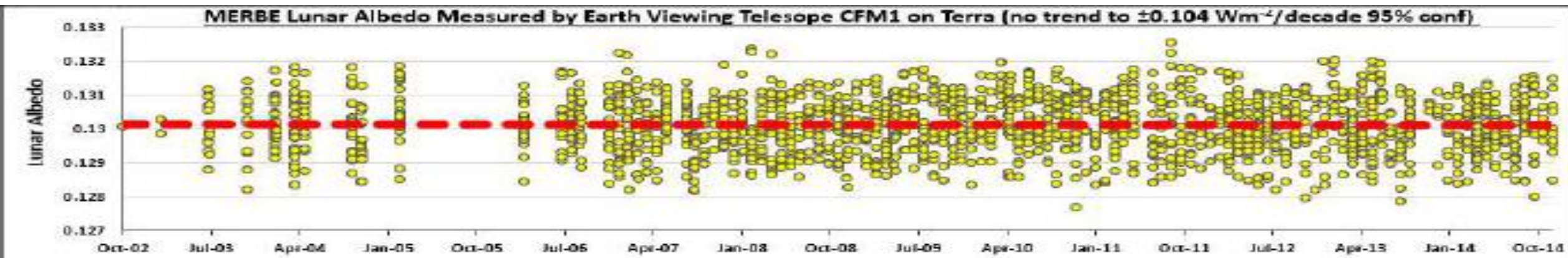
### Correspondence to:

## NASA CERES Spurious Calibration Drifts Corrected by Lunar Scans to Show the Sun Is not Increasing Global Warming and Allow Immediate CRF Detection

Grant Matthews<sup>1</sup>

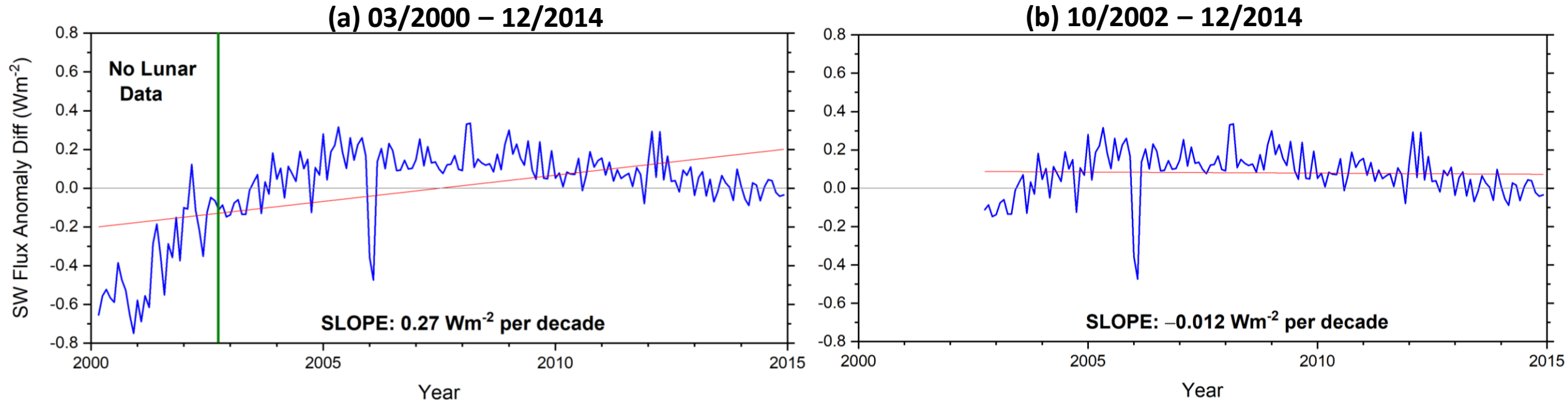
<sup>1</sup>Zedika Solutions LLC, Fort Wayne, IN, USA

**Abstract** Orbital Earth Radiation Budget measurement comparisons to models, are critical for climate prediction confidence. Satellite systems must reduce calibration drifts for this purpose. NASA Clouds and the Earth's Radiant Energy System (CERES) measures Earth albedo reductions that if correct, would increase solar forcing and suggest greater sunlight absorption is driving much of recent temperature increases. Such results are presented, alongside those from the Moon and Earth Radiation



*“Moon and Earth Radiation Budget Experiment (MERBE) uses constant lunar reflectivity for tracking and compensation of instrument telescope degradation, undetectable by CERES.”*

# MERBE minus CERES\_SSF1deg\_Terra SW Flux Anomaly Difference



- MERBE “corrects” the 15-year trend measured by CERES by making large adjustments during the period prior to CERES lunar scanning (Figure a).
- There is no trend difference between MERBE and CERES during the period after CERES lunar scanning began (Figure b).
  - **MERBE lunar analysis confirms that CERES Terra is stable during the period when CERES lunar scans are available!**

# **CERES Journal Publications and Citation Counts**

## **(For Papers Between 1993-2021; Updated October 7, 2021)**

- Total number of peer-reviewed journal articles: 2,268
- Total number of citations to CERES papers: 91,831

(Compiled by Dennis Keyes)

# Number of Unique Users by CERES Data Product

(through September 30, 2021)

Level	Product	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1b	BDS	9	14	19	14	11	13	14	10	12	19	5
2	SSF	77	138	223	247	253	278	327	235	251	229	166
	FLASH_SSF	8	15	23	30	61	41	68	101	92	97	72
	CCCM	32	33	37	28	55	54	49	49	36	37	29
	ES8	20	18	31	16	21	15	15	10	8	8	0
	SSF-MISR	4	2	5	4	2	1	3	1	1	4	2
3 & 3b	EBAF	160	410	602	731	787	783	935	928	995	1010	735
	SYN1deg	168	199	353	382	438	494	607	639	754	827	629
	SSF1deg	126	107	157	166	160	194	190	159	221	199	157
	CldTypHist	12	37	57	41	40	47	86	87	79	84	59
	FluxByCldTyp										44	50
	ES4	36	11	27	19	13	12	17	17	17	10	5
	ES9	12	5	13	9	5	5	8	6	6	3	1
	FLASH_TISA	18	20	17	15	15	36	52	65	81	127	89

FLASHFlux via POWER since last year: 94,800

## Changes to Terra and Aqua MLT

### Terra:

- Completed all Inclination Adjust Maneuvers (IAMs) related to maintaining a 10:30 mean local time (MLT) equator crossing and 705 km orbit altitude.
- Began drifting to an earlier MLT in April 2021.
- In October 2022, will reach and exceed a 10:15 AM MLT crossing corresponding to a constellation exit with lower orbit altitude (694 km).
- MLT will continue to drift after this, reaching 9:00 AM around December 2025.

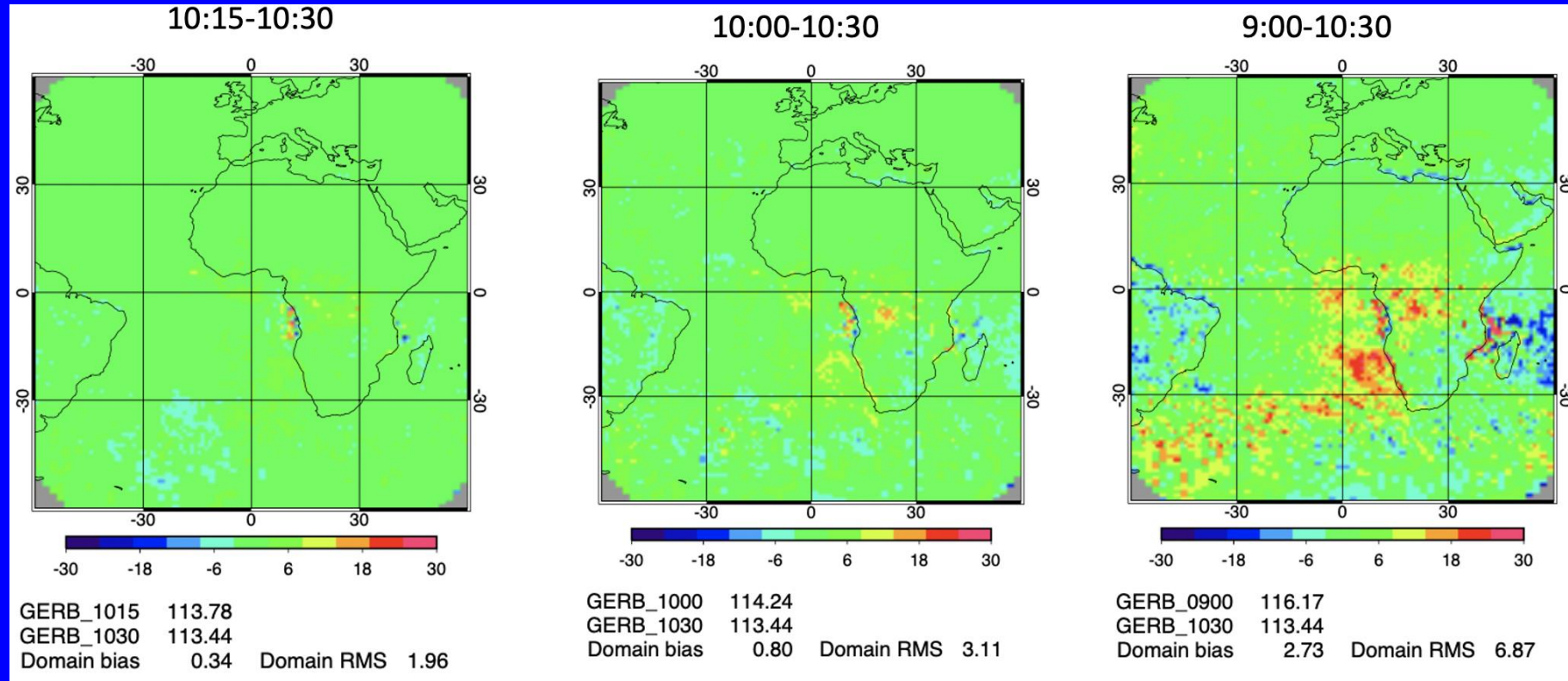
### Aqua:

- Completed all IAMs related to maintaining a 13:35 MLT equator crossing and 705 km orbit altitude.
- Will begin drifting to a later MLT in January 2022. Will also exit A-Train constellation with lower orbit altitude (685 km). **Proposed new plan is to delay lowering the orbit until June 2024.**
- By Fall of 2022, will reach and exceed a 13:50 PM MLT crossing. **Proposed new plan: June 2023**
- MLT will continue to drift after this, reaching 15:34 PM around September 2025. **Proposed new plan: Mission continues until August 2026 with MLT of 15:51 PM.**

**Question:** At what point does a drift in MLT start impacting the quality of the CERES climate data record (e.g., EBAF)?

# Impact of a Change in MLT on SW Reflected Solar Radiation

- Compare GERB SW TOA flux at 10:15 am, 10:00 am and 9:00 am vs 10:30 am
- Normalize each observation to a common 10:30 am solar geometry



- To avoid discontinuity in CERES record, MLT must remain < 15 min of 10:30 am for Terra and 1:30 pm for Aqua.
- By fall of 2022, CERES EBAF CDR will be reprocessed and incorporate transition from Terra+Aqua to NOAA-20.
- **Details about planned EBAF reprocessing will be discussed in today's "EBAF Update" presentation.**
- SSF & SSF1deg products will continue to be produced for Terra and Aqua.



# Planning for Terra & Aqua Edition 5

## Main Considerations:

- 1) GMAO improvements to their atmospheric reanalysis system.
  - CERES and GMAO hold WebEx meetings every 3 weeks to gauge progress and provide ongoing validation results for the latest GEOS FP or FPIT version.
- 2) MODIS Collection 7 schedule.
- 4) CERES production code improvements.
- 5) CERES algorithm improvements (particularly those enabling a seamless transition across satellite platforms).

New logo created by **Aimée Amin**, Graphics Designer, Science Directorate Communication Team. Thanks!

### Old COVE Website:

- COVE webpages were still on an old stand-alone box.
- They have now been moved to virtual machines.
- The physical web presence of [cove.larc.nasa.gov](http://cove.larc.nasa.gov) has been distributed between [science.larc.nasa.gov/crave](http://science.larc.nasa.gov/crave) and [science-data.larc.nasa.gov/crave](http://science-data.larc.nasa.gov/crave).

## CERES Radiation And Validation Experiment (CRAVE)

- Thermo-electric coolers replaced on LaRC MPLNET.
- Added internal and external blowers to solve a window condensation problem.
- Painted MPLNET enclosure.
- Installed new PAR instrument

Next Granite Island trip will be week of Oct. 18

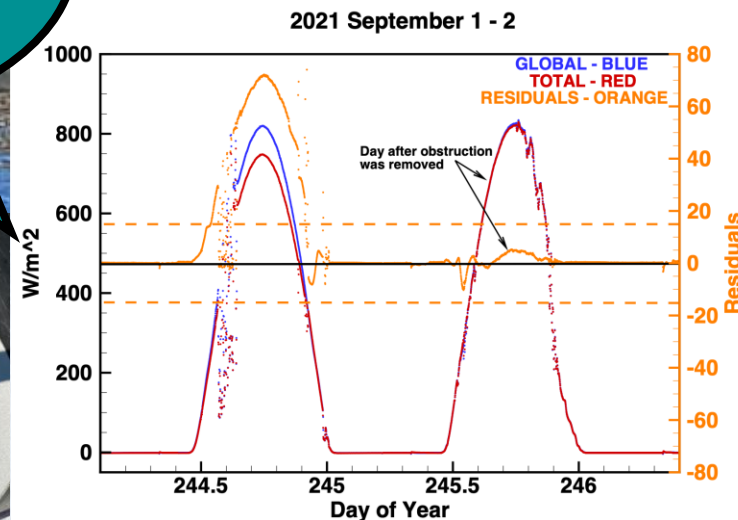
First post-COVID Granite Island maintenance trip in June 2021 after 20 months of remote operations!!

Newly cal'd SW and LW instruments; New spectral sunphotometer installed



Some things can not be done remotely. Stubborn deposit was affecting the component summation residuals; it was finally scraped off with a razor blade by our colleague **John Lenters**. Thanks!

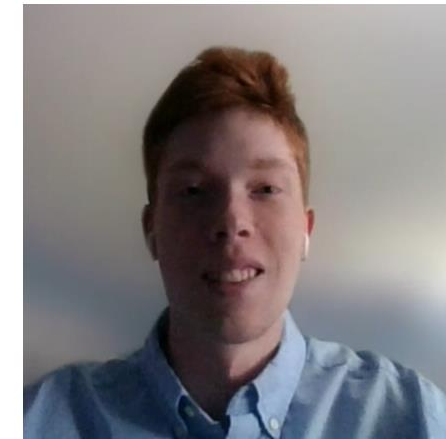
NMU intern helped with Summer GI trip, and other local help made timely repairs as needed. Intern also did daily data checks, analyzed fluxes for anomalies, and created residual plots.





# GLOBE Clouds Accomplishments

- **Over 220k GLOBE Clouds observations** were received FY21 (Oct 1, 2020-Sept 30, 2021). Over **75k satellite match emails** were sent out. **86% of observations matched to one or more satellites.**
- The NASA GLOBE Clouds team as well as multiple CERES scientists received the **2021 Robert H. Goddard Award – Outreach Teams** for exceptional innovation reaching families and the public at home during the COVID-19 pandemic.
- The NASA GLOBE Clouds team partnered with SatCORPS to mentor **summer student to study** observations taken during the [Solar Terminator](#). The work has been featured in a blog post.
- The team is planning the **2022 Winter Cloud Challenge: Clouds and Our Climate**. This intense observation period will focus on the role of clouds in climate. It will take place **January 15 – February 15, 2022.**



Summer Intern  
Mr. Ryan  
Moore.  
Mr. Moore is a  
junior in  
Information  
Science at the  
University of  
Maryland  
(UMD)



# CERES Science Team Meeting

## TEST YOUR CLOUD OBSERVATION SKILLS!

1. Download the GLOBE Observer app to your mobile device
2. Select "Create an Account"
  - a. Enter the email you wish to use and select your country affiliation
  - b. Enter Referral Code: **GLIDSMU7** (*This will connect everyone to the same GLOBE Team*)
  - c. Select "Create Account"
  - d. An email will be sent to this address with a password to be used on the next screen
  - e. Enter the password
3. Select GLOBE Clouds to make a sky observation!



## Other News

- Request for over-guide to help support participation in Libera pre-launch work has been granted.
- Terra Solid State Recorder (SSR) Data Memory Unit (DMU) Reset
  - Terra had suffered two printed wire assembly (PWA) anomalies in late June, one each to the MODIS and MISR supersets.
  - The failure on the MODIS buffer had put MODIS at further risk of data loss.
  - An SSR DMU reset was performed on September 22 to recover the failed PWAs.
  - All of the PWAs were cycled and ALL have come back online and assigned to their appropriate sensor supersets.
- Aqua Deep Space Calibration Maneuver (September 23—First one for Aqua).
- Bruce Wielicki awarded Warren Washington Award. Thank you to Dennis Hartmann for putting the nomination forward.
- Syukuro Manabe award Nobel Prize for Physics.

# Upcoming Conferences & Meetings of Interest

## Fall AGU

- December 13-17, 2021, New Orleans, LA / Hybrid.

## AMS Annual Meeting

- January 23-27, 2022, Houston, TX / Hybrid.

## Spring 2022 CERES Science Team Meeting

- April 26-28, 2022, NASA LaRC / Virtual?

## International Radiation Symposium (IRS)

- July 4-8, 2022, Thessaloniki, Greece.

## AMS 16<sup>th</sup> Conference on Cloud Physics & Atmospheric Radiation

- August 8-12, 2022, Madison, WI.

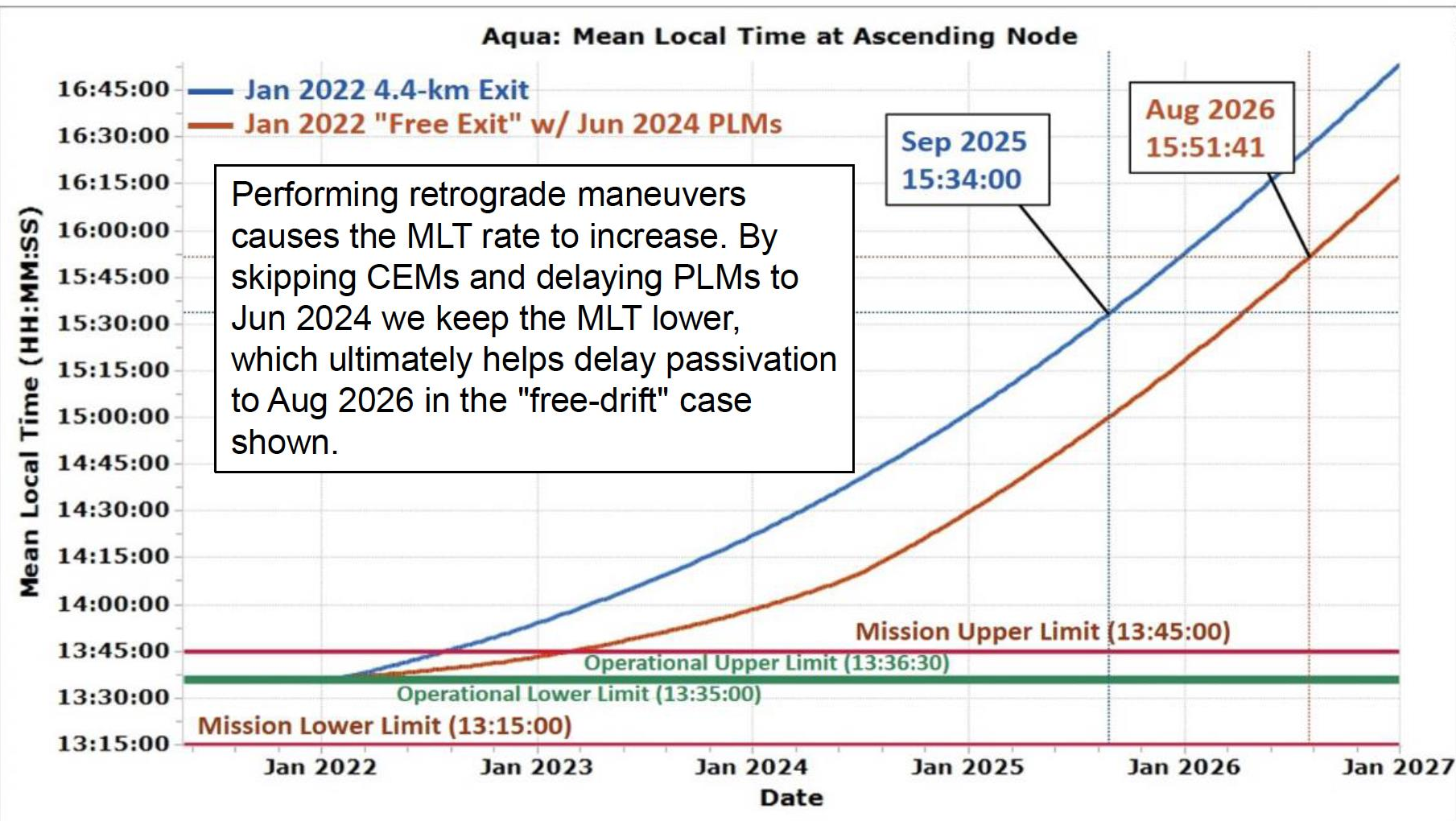


**Backup Slides**



# Mean Local Time (MLT)

## Jan 2022 Baseline vs. Free-Drift/No-Exit: June-July 2024 PLMs





# SSR DMU Reset Summary



- **On 6/28/2021, the MISR buffer experienced a PWA failure with PWA #40**
  - The failure on the MISR buffer had the MISR IOT reduce their BAP observations
- **On 6/29/2021, the MODIS buffer experienced a PWA failure with PWA #47**
  - The failure on the MODIS buffer had put MODIS at further risk of data loss, after reducing observations for a PWA failure in 2020
- **The MODIS Buffer capacity was so low to warrant a SSR Reset**
  - An SSR Reset was believed to be able to recover the failed PWAs
    - A 2001 Reset (triggered by SSR Halt Anomaly) successfully recovered the first PWA failure
  - FOT had discussed with IOTs in 2019 what their capacity threshold was requiring an SSR reset
- **Prior to requesting approval to perform an SSR reset, the FOT looked into several alternatives to a reset**
  - Increased Contacts and reduced Science collection
  - Neither were deemed sufficient to mitigate the data loss risk and science impacts
- **FOT prepared reset procedures**
  - Focused on SSR Data Memory Unit (DMU) reset
  - Developed extensive script to perform reset then remap all Supersets
    - Included various contingencies such as partial recovery of offline PWAs
  - Several simulations were conducted in to validate procedures and get FOT familiar with the procedures.
- **Independent review boards/working groups were held in preparation for the reset (Approvals were received at all briefings)**
  - 08/10/2021 - Terra SSR Reset Engineering Independent Peer Review
  - 09/13/2021 – ESMO Code 400 briefing - Reset of the Terra SSR
  - 09/15/2021 – ESMO Special Topic Briefing to Code 100
  - 09/17/2021 – NASA HQ Terra SSR Reset Briefing